Hydropower Systems in a Warmer Pacific Northwest

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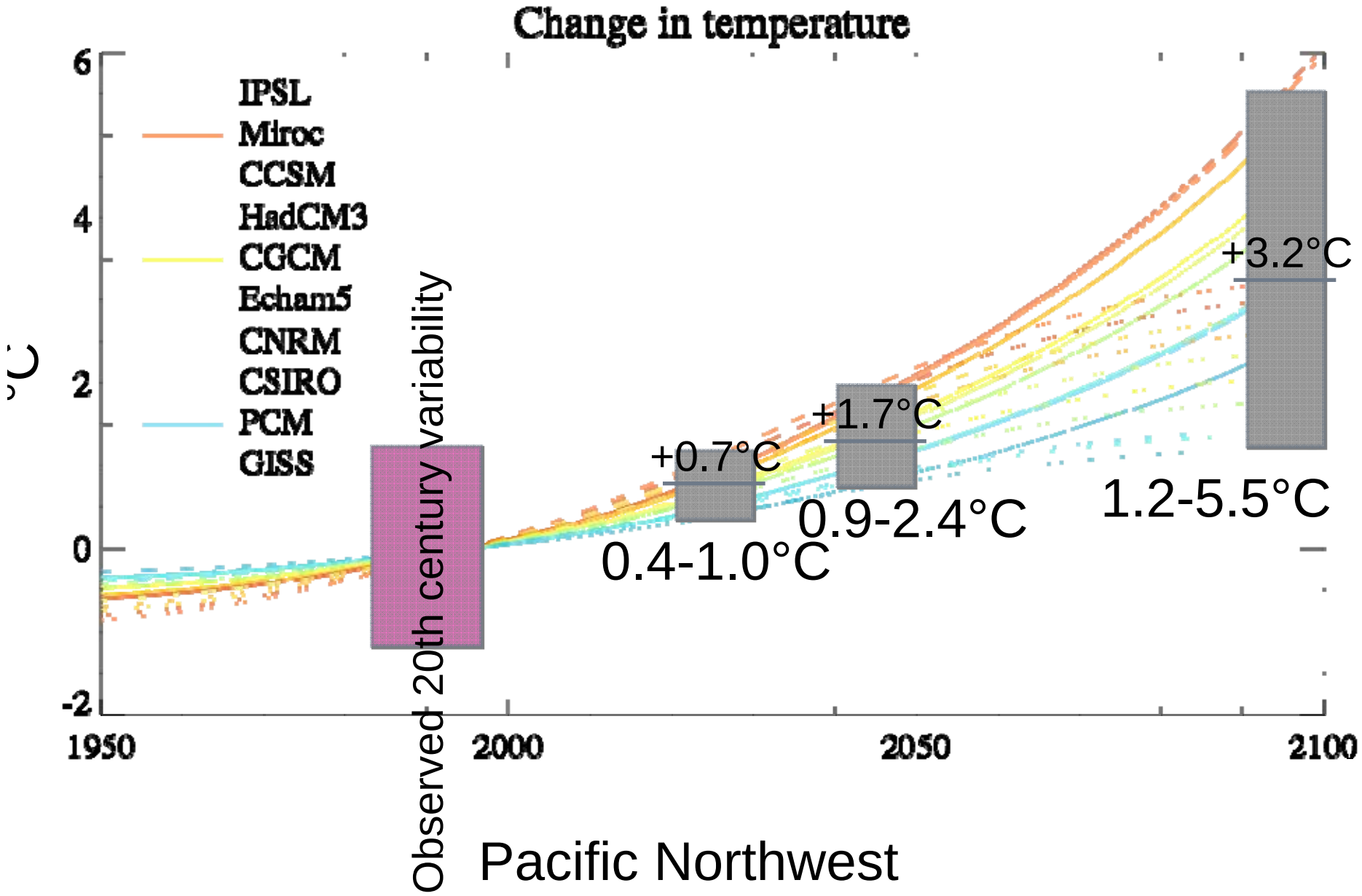
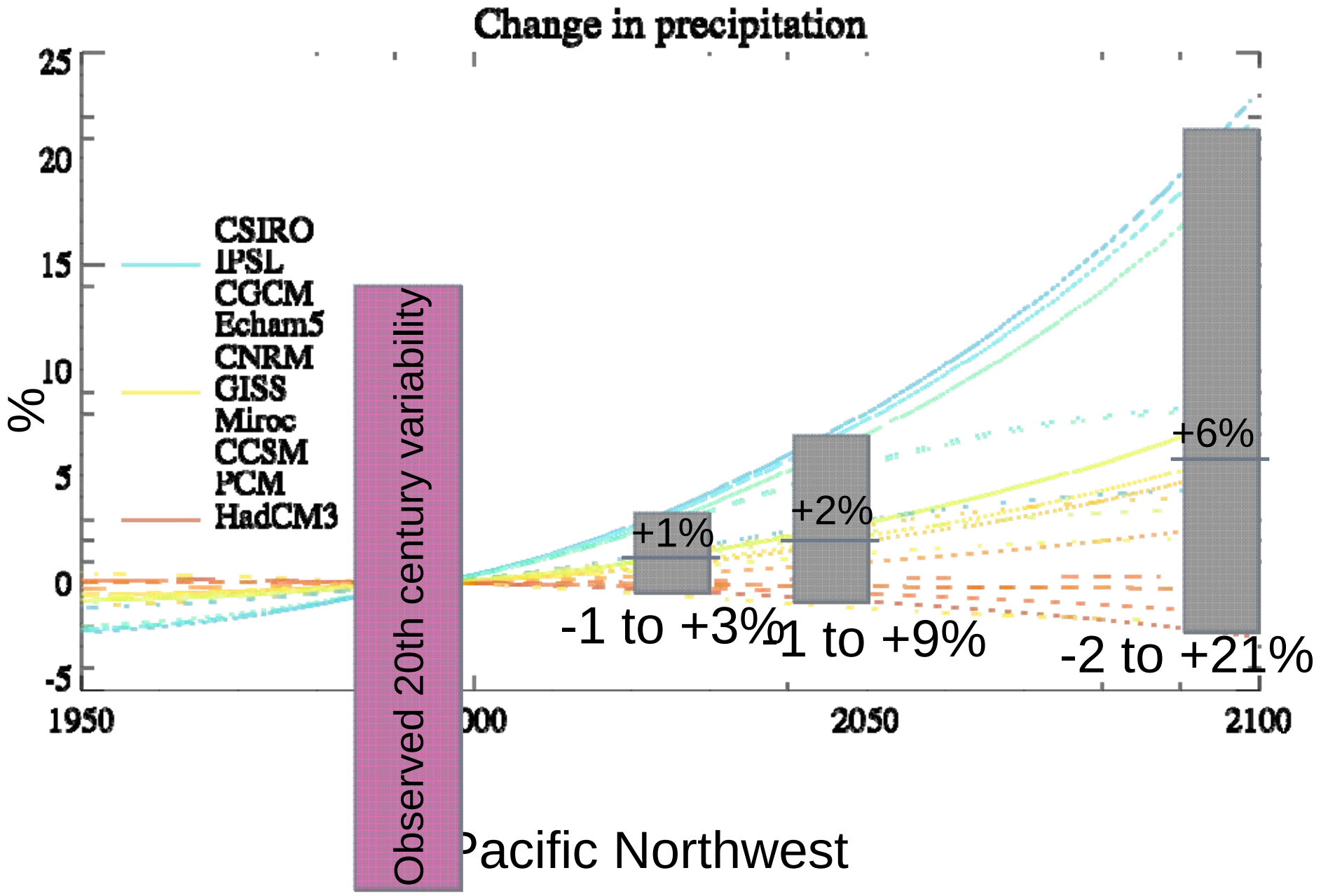

Change in temperature
IPSL
Miroc
CCSM
HadCM3
CGCM
Echam5
CNRM
CSIRO
PCM
GISS
°C
6
4
2
0
-2
1950
2000
2050
2100
Observed 20th century variability
+0.7°C
0.4-1.0°C
+1.7°C
0.9-2.4°C
+3.2°C
1.2-5.5°C
Pacific Northwest

Conclusion:

- Future warming is projected with a high level of certainty.



Pacific Northwest

Conclusions:

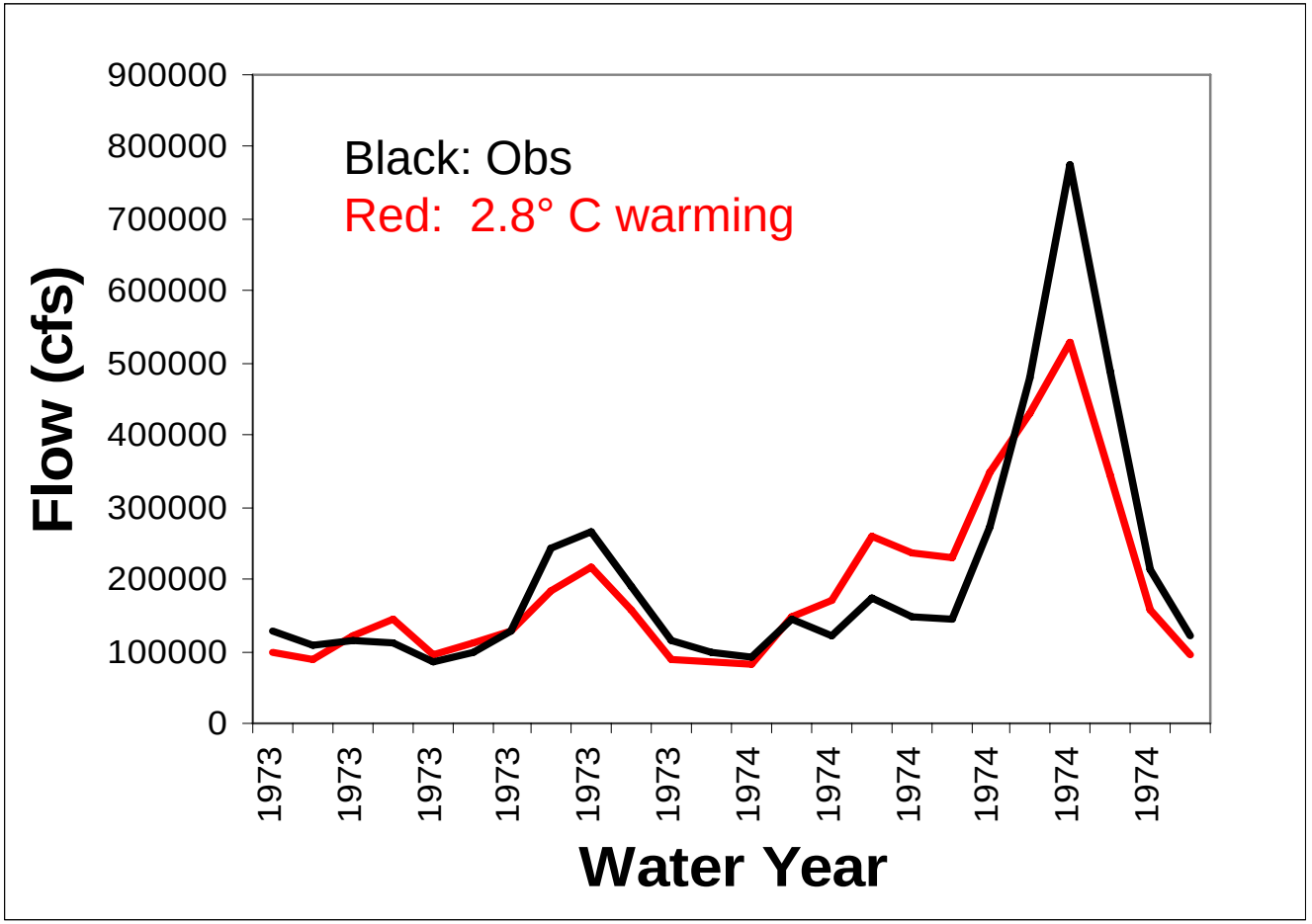
- Future precipitation is projected with much less certainty.
- Systematic changes may be small.
- Expect “warm and wet” AND “warm and dry” at different times in the future.

Warming Affects Streamflow *Timing*

Temperature warms, precipitation unaltered:

•Streamflow timing is altered

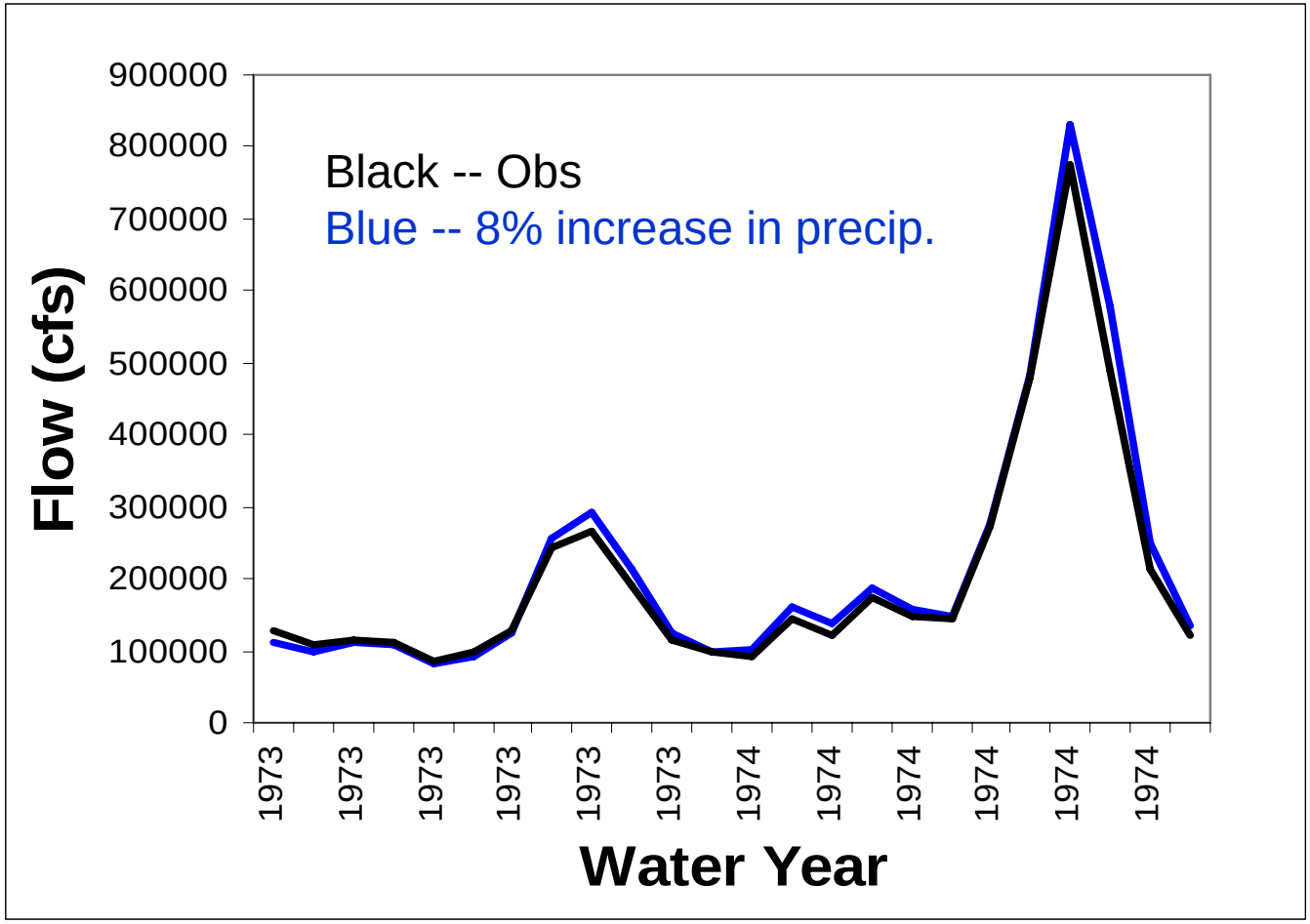
• Annual volume may be somewhat lower due to increased ET



Precipitation Affects Streamflow *Volume*

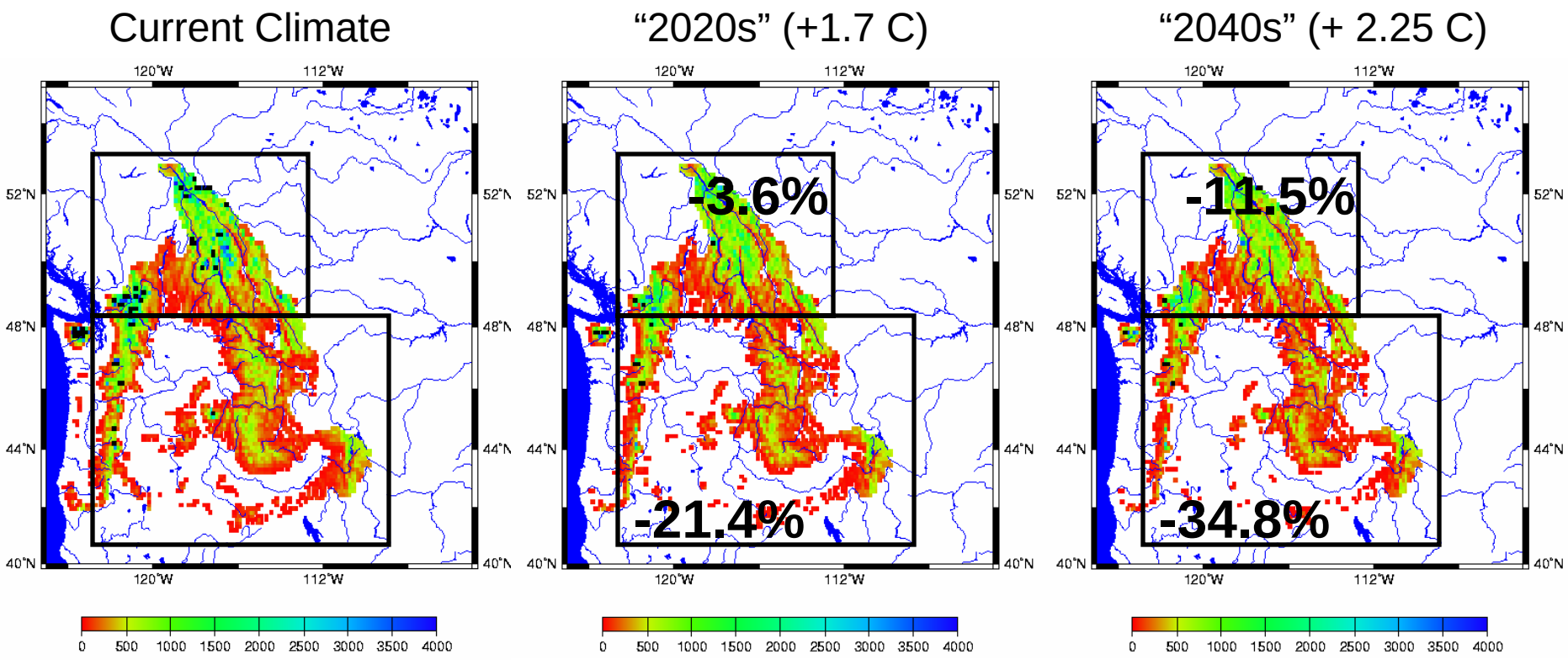
Precipitation increases, temperature unaltered:

- Streamflow timing stays about the same
- Annual volume is altered

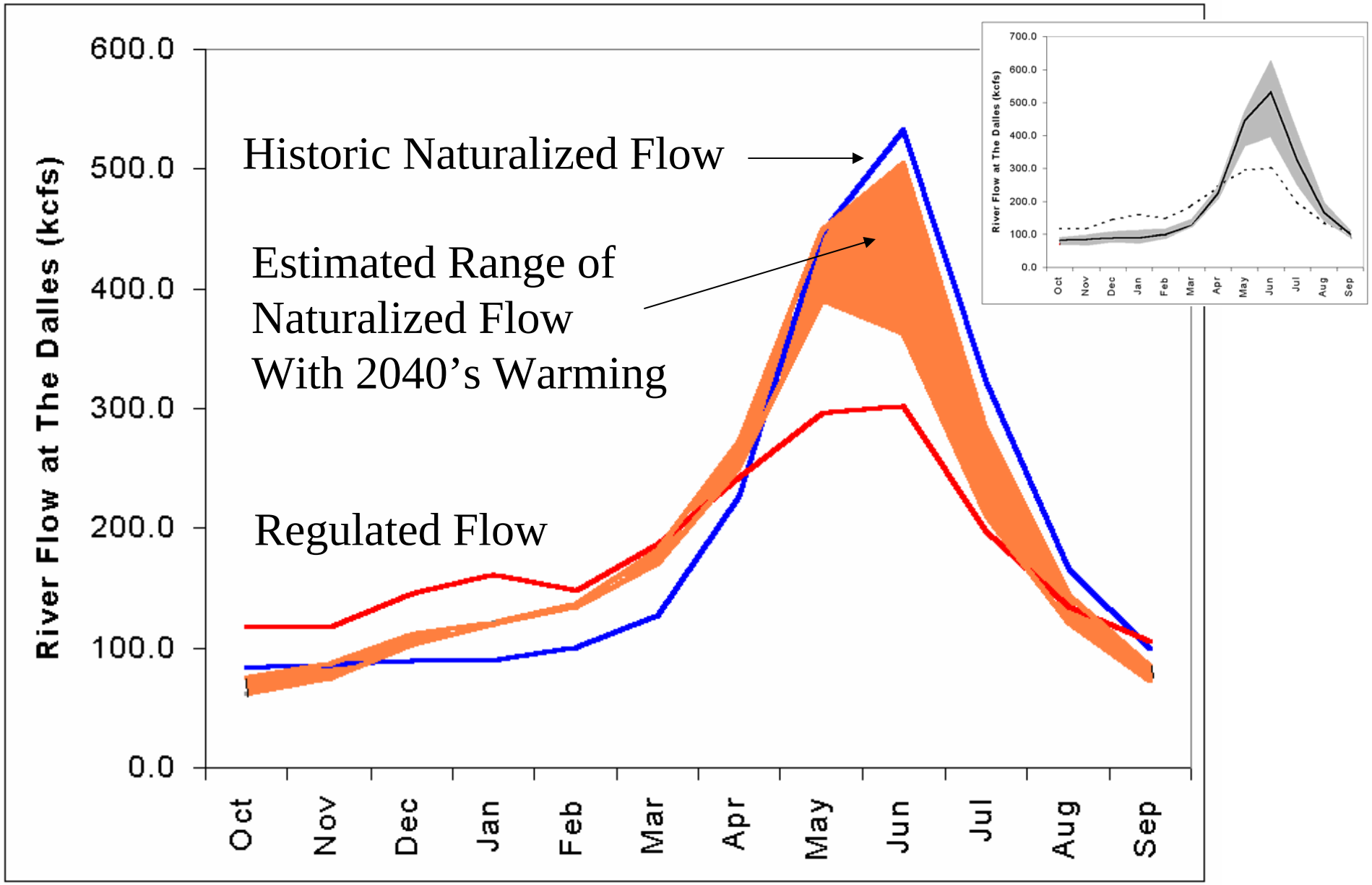


Changes in Simulated April 1 Snowpack for the Canadian and U.S. portions of the Columbia River basin

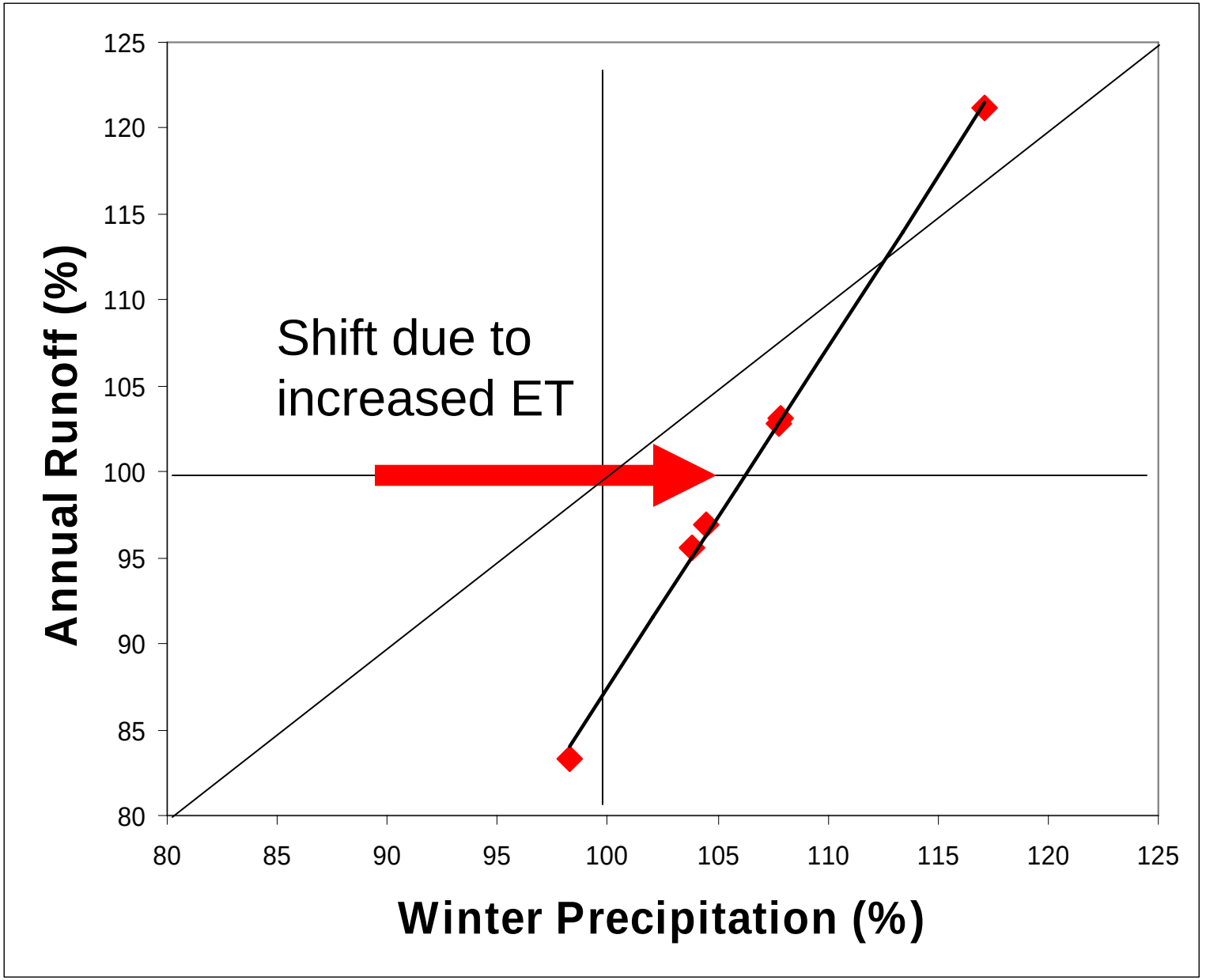
(% change relative to current climate)



Naturalized Flow for Historic and Global Warming Scenarios Compared to Effects of Regulation at 1990 Level Development

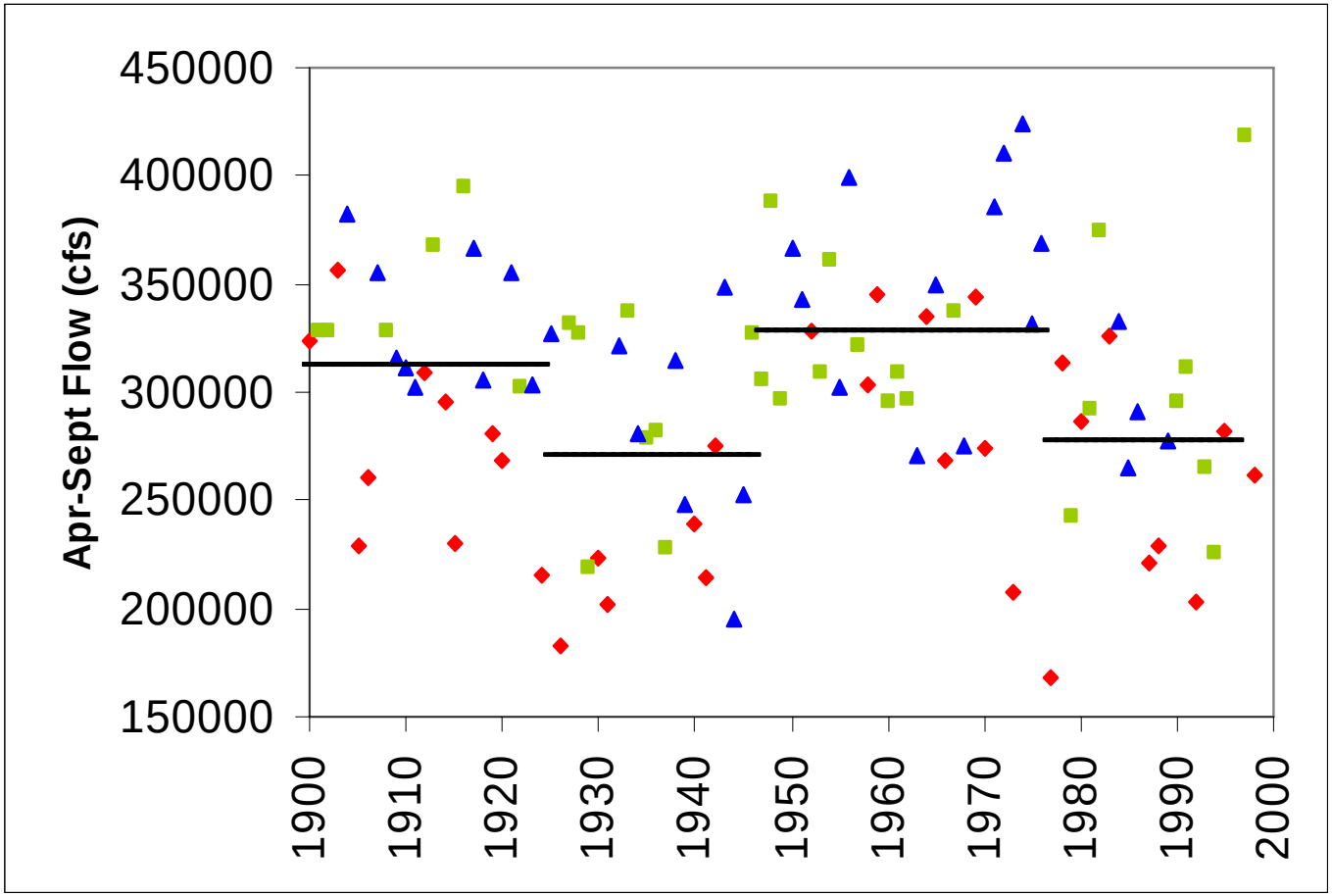


Change in Winter Precipitation vs Change in Annual Runoff From Six Climate Change Scenarios



Will Global Warming be “Warm and Wet” or “Warm and Dry”?

Answer: Probably BOTH!



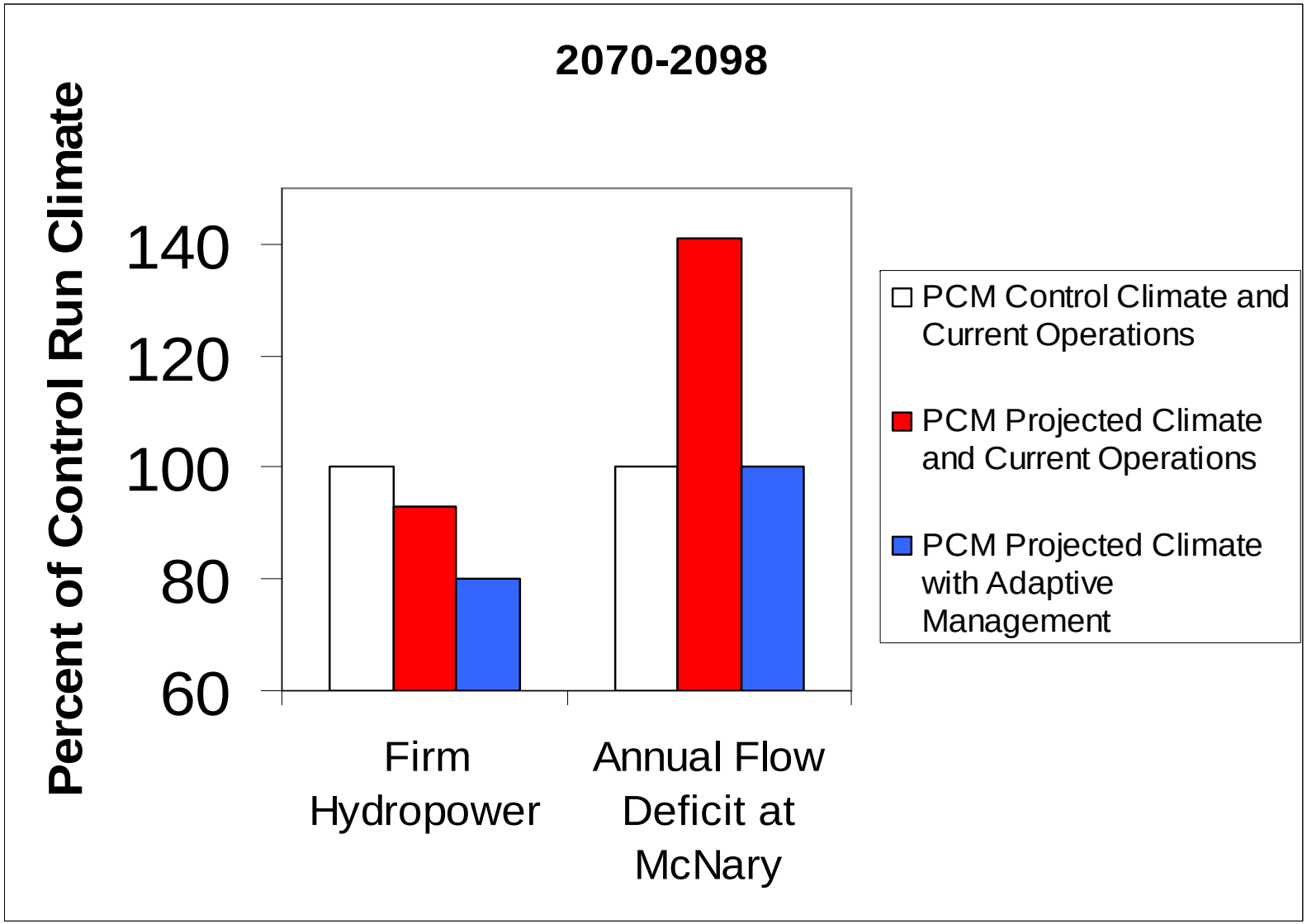
- Hydropower is usually one objective of many in a water resources system

- Changes in climate will potentially affect most if not all of these inter-related factors

Flood Control
Urban Water Supply
Irrigation
Hydropower
Recreation
Navigation
Instream Flow Augmentation
Water Temperature
Gas Content
Transboundary Agreements
ESA

Conventional Energy Resources
Conservation and Renewables
Energy Demand and Markets
Inter-Regional Energy Transfers
Population and Demographics

Adaptation to climate change will require complex tradeoffs between ecosystem protection and hydropower operations



Source: Payne, J.T., A.W. Wood, A.F. Hamlet, R.N. Palmer, and D.P. Lettenmaier, 2004, Mitigating the effects of climate change on the water resources of the Columbia River basin, Climatic Change, Vol. 62, Issue 1-3, 233-256

Overview of Talks

John Fazio—Climate change impacts to the Columbia River hydropower system

Matt Markoff– Assessing the range of climate uncertainties in Columbia Basin hydropower planning

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Cliff Mass—Downscaling using high-resolution climate models and the challenges of assessment at smaller spatial scales

Rhys Roth —Role of conservation and renewables

John Martin—Role of combined heat and power systems